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SPACE RADIATION STUDIES

for the reporting period:

June 1983 - July 1984

Submitted by: Cosmic Ray Laboratory

The University of Alabama in Huntsville

Huntsville, Alabama 35899

SUMMARY

During this period the two Active Radiation Dosimeters (ARD's) were flown on Spacelab I, performed without fault and were returned to Space Science Laboratory, MSFC for recalibration. During the flight in December 1983, performance was monitored at the Huntsville Operations Center (HOSC). Despite some problems with the Shuttle data system handling the VFI, it could be established that the ARD's were operating normally. Postflight calibrations of both units determined that sensitivities were essentially unchanged from preflight values. Flight tapes have been received for approximately 60% of the flight and it appears that this is the total available. The next phase of effort will involve close collaboration with Space Science Laboratory, MSFC, in the analysis of this data.

Also during the period, the Nuclear Radiation Monitor (NRM) was under assembly and testing at MSFC. Support was rendered in the areas of materials control and parts were supplied for the supplementary heaters, dome gas-venting device and photomultiplier tube housing. Performance characteristics of some flight-space photomultipliers were measured. The next phase of effort in the NRM will involve an intensive program of software development.

Post-Flight Calibration of ARD's - 1 and - 2

The instrument (actually #2) is shown in Figure 1. Full details of calibration of these instruments was given in the pre-flight calibration report: Annual Report on Contract NAS8-31170, Calibration of Active Radiation Detector for Spacelab - 1, December 1982, The University of Alabama in Huntsville.

The experimental setup used is shown in Figure 2. Both source and detector are at a fixed distance ($\sim$ 1 m) from the floor. The source position was unchanged but the detector and shield were on a movable trolley. The source used was a nominal 100 m Ci of Cs-137 (New England Nuclear NER 401 H, serial number CS-315) of actual activity 93.8 $\pm$ 5 m Ci on August 8, 1975. At the time of this calibration, February 1984, its activity was 77.1 m Ci.

The ARD was placed in the γ-field so that the IC and both PC's were equidistant, d meters, from the source. The number of counts per unit time for each detector was recorded. For the PC's the mean of 17 measurements of counts per second was taken in each case. For the ion chamber, the counting interval was varied depending on the count rate so that the uncertainty in counting was less than 3%. At count rate > 50 per 100 s a counting period of 100 s is adequate. At lower count rates longer interval were used, and at very low rates of a few per 100 s or less, the measurement was made of the intervals between actual counts. This is conveniently done with the GSE since the count register of the ARD is read out and displayed every second by the GSE.

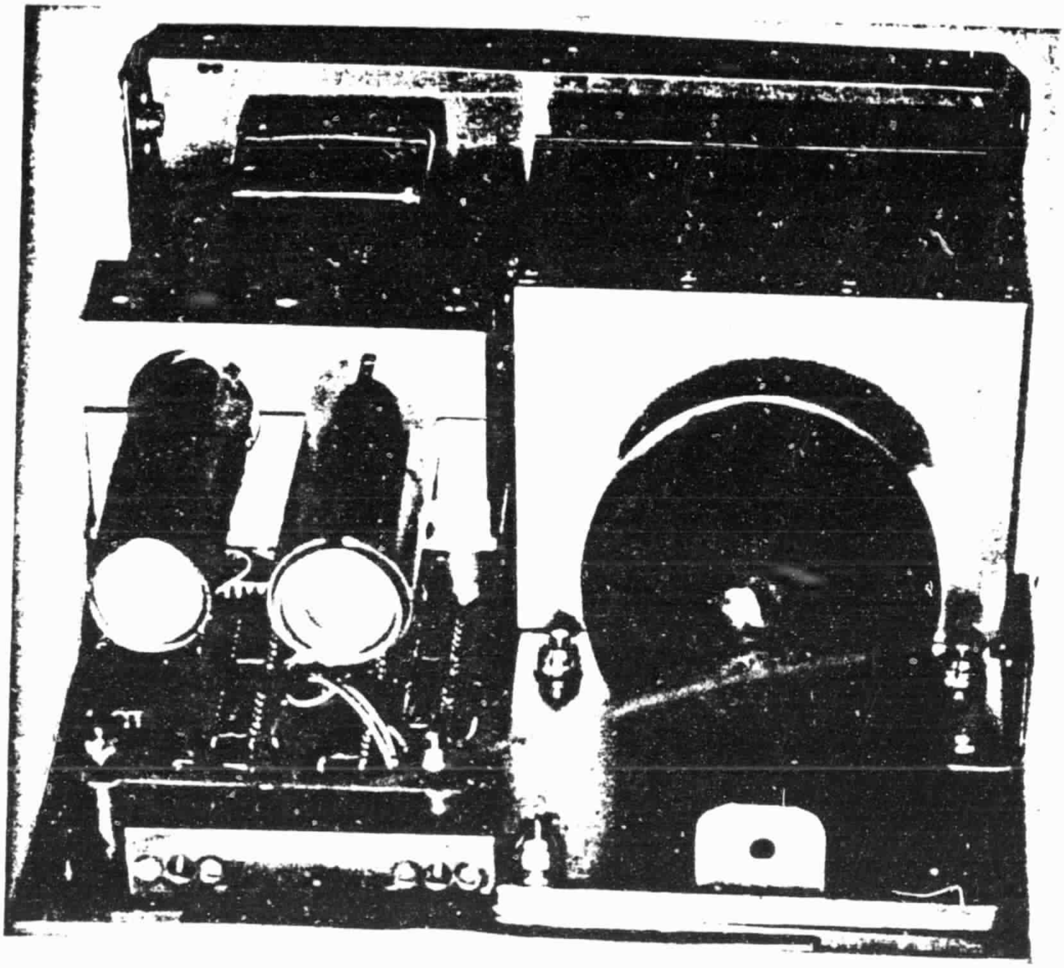
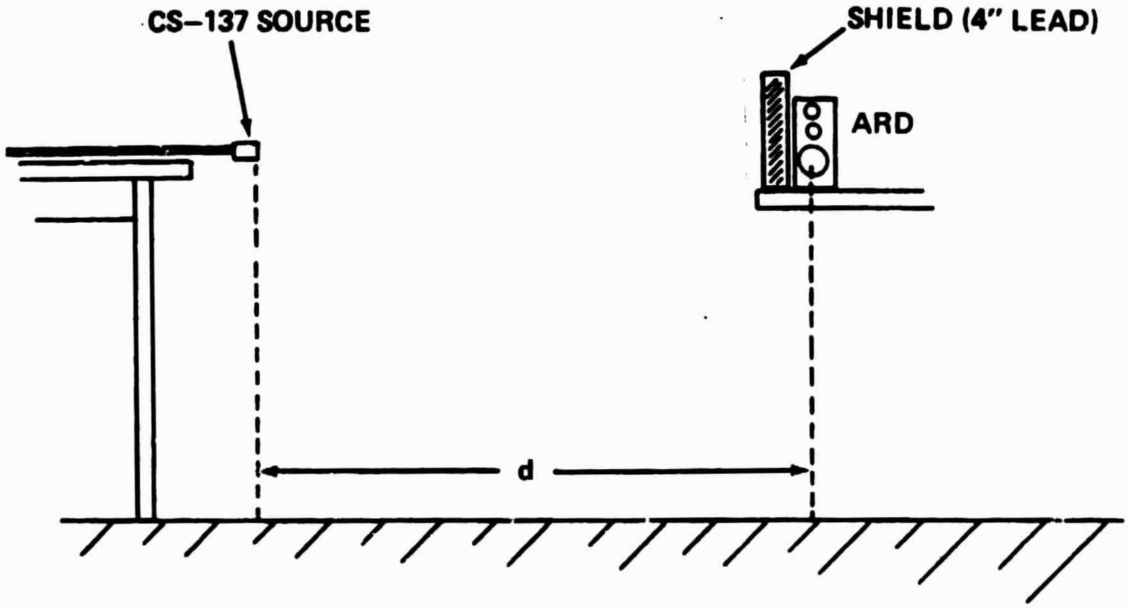


FIGURE 1. ACTIVE RADIATION DETECTOR
(PROTECTIVE COVER REMOVED)



ARD CALIBRATION

EXPERIMENTAL SETUP: SHADOW SHIELD METHOD

FIGURE 2.

Figure 3 shows the calibration data for both ion chambers after the flight. (circled crosses) The values have been adjusted for the decay of the source. The uncircled crosses and solid lines are the pre-flight calibrations made in January 1983, a little over a year earlier. It may be seen that within experimental error the sensitivities are unchanged. The values of sensitivity were determined to be:

S/N - 1 6.3 ± .3 (6.1) μ rad per count

S/N - 2 10.3 ± .4 (10.4) μ rad per count

Values given in the preflight calibration report are shown in parenthesis.

Figure 4 compares the count-rates of the proportional counters in the two units when placed in γ - fields of the same intensity. Two observations are made: All counters respond similarly to these fields at count-rates at least up to several thousand cps, the thresholds on PC-1's in the two units are identical, while the threshold in the PC-2 of S/N - 2 was a little lower causing a 4% difference in count-rate. For anticipated purposes of this data, the difference is immaterial.

It may also be noted that the counters with 1.27 mm copper shield showed rates approximately 10% less than their unshielded counterparts. This is in agreement with calculated absorption loss (8%). The shield would be more effective against soft electrons, should these be encountered.

Figures 5 and 6 show the correspondance between the ion chamber and the PC's (corrected for scattered radiation) after and before the flight respectively. Again, no significant change in behavior is observed.

Fig. 3

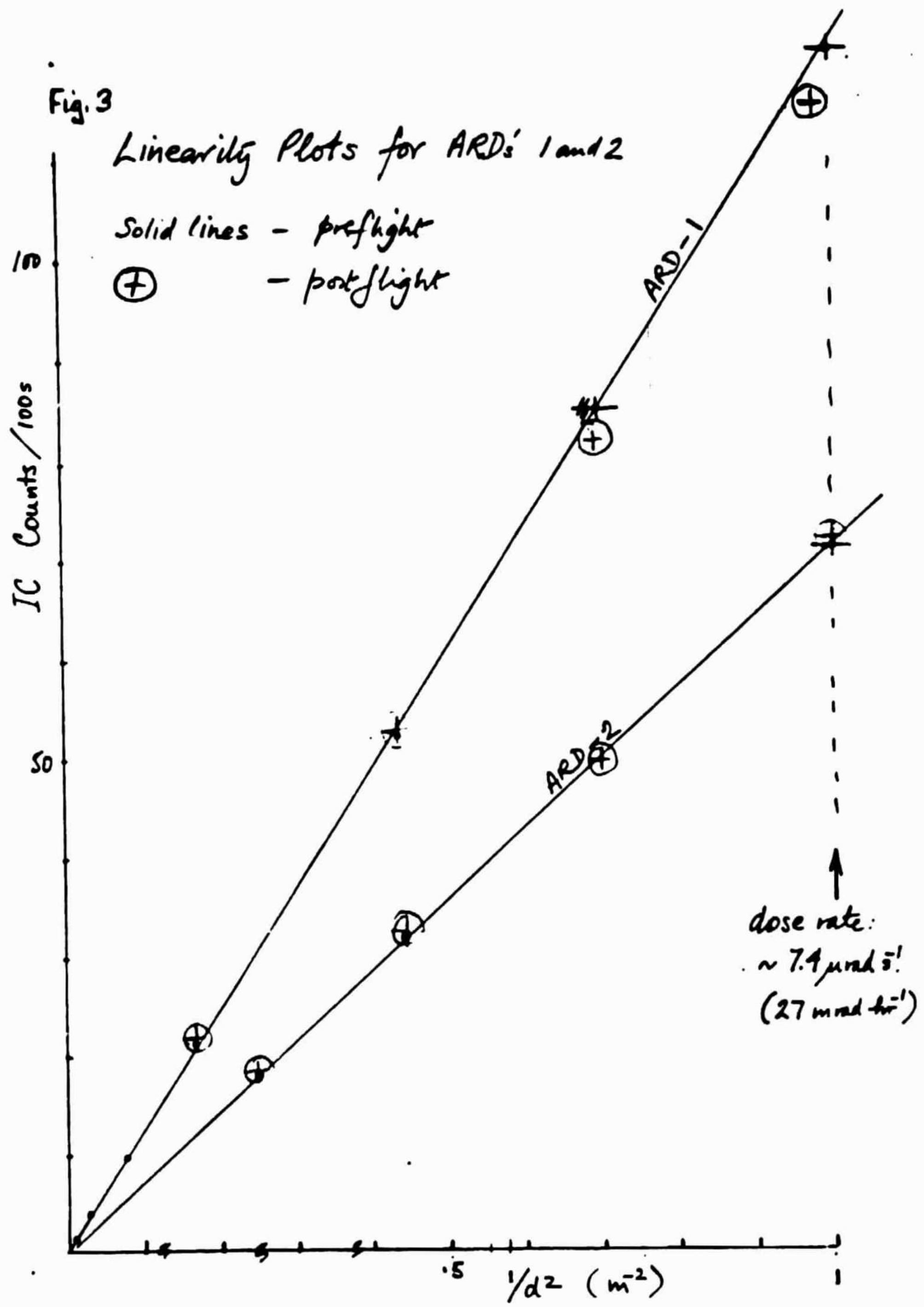

Linearity Plots for ARD's 1 and 2
Solid lines - preflight
⊕ - postflight
ARD-1
ARD-2
100
50
IC Counts / 100s
·5
1/d² (m⁻²)
dose rate:
~ 7.4 μrad s⁻¹
(27 mrad hr⁻¹)

Figure 4 15 Feb 84

COMPARISON OF ARD'S 1 AND 2
PROPORTIONAL COUNTERS:
COUNT RATIOS IN γ-FIELD

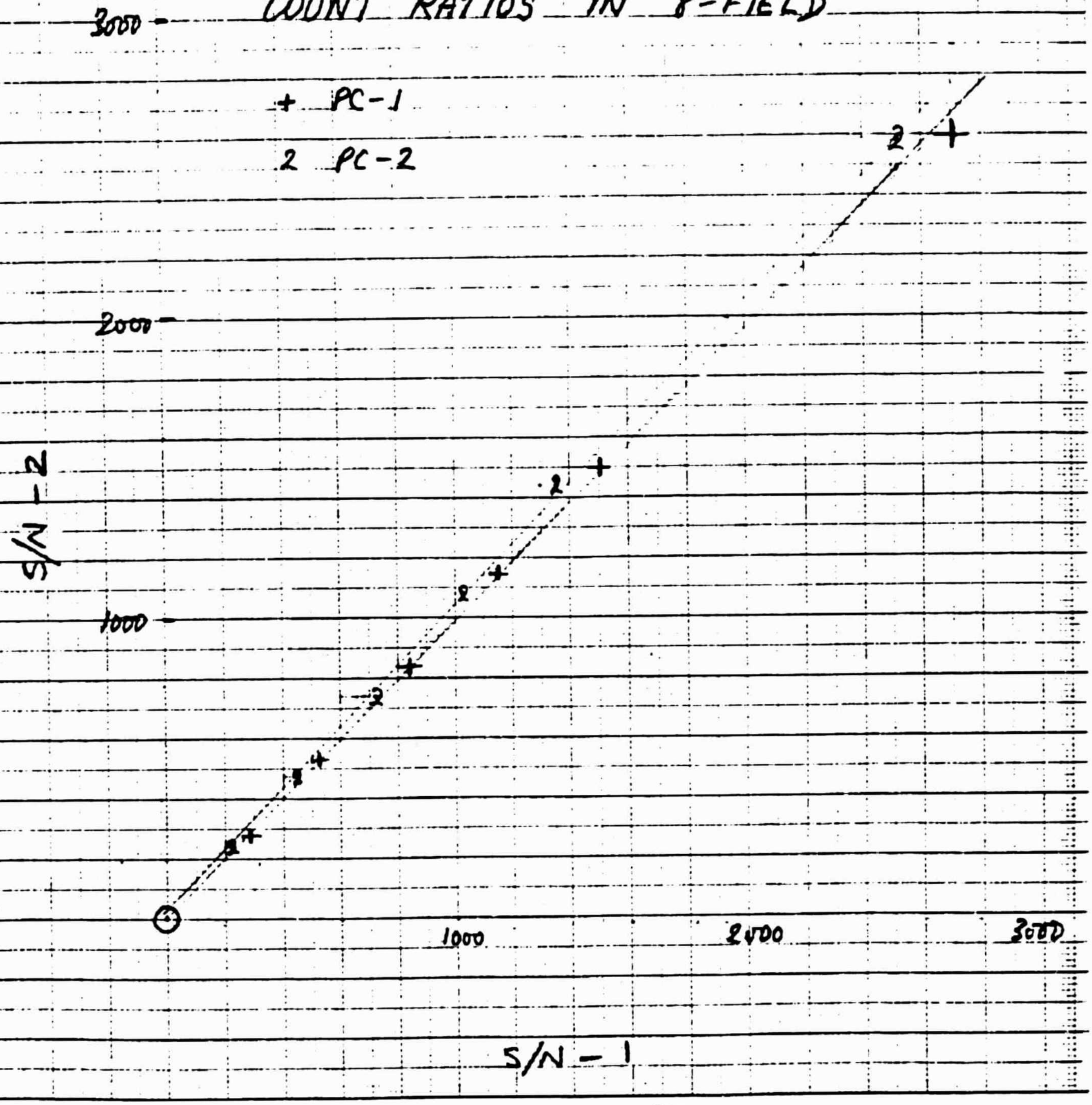
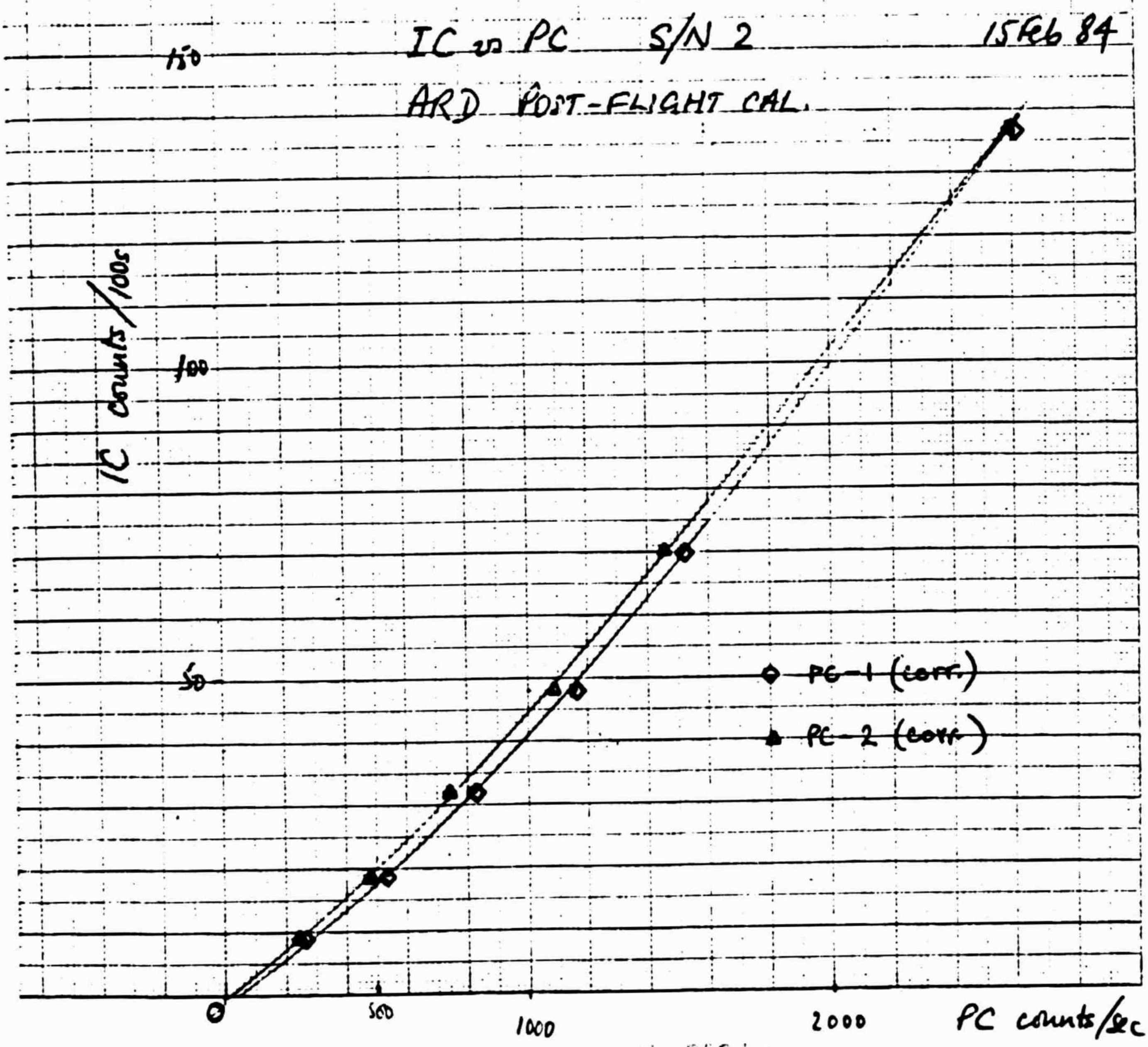


Figure 5


IC vs PC S/N 2
15 Feb 84
ARD POST-FLIGHT CAL.
150
100
50
IC counts/100s
◇ PC-1 (corr.)
▲ PC-2 (corr.)
0
500
1000
2000
PC counts/sec

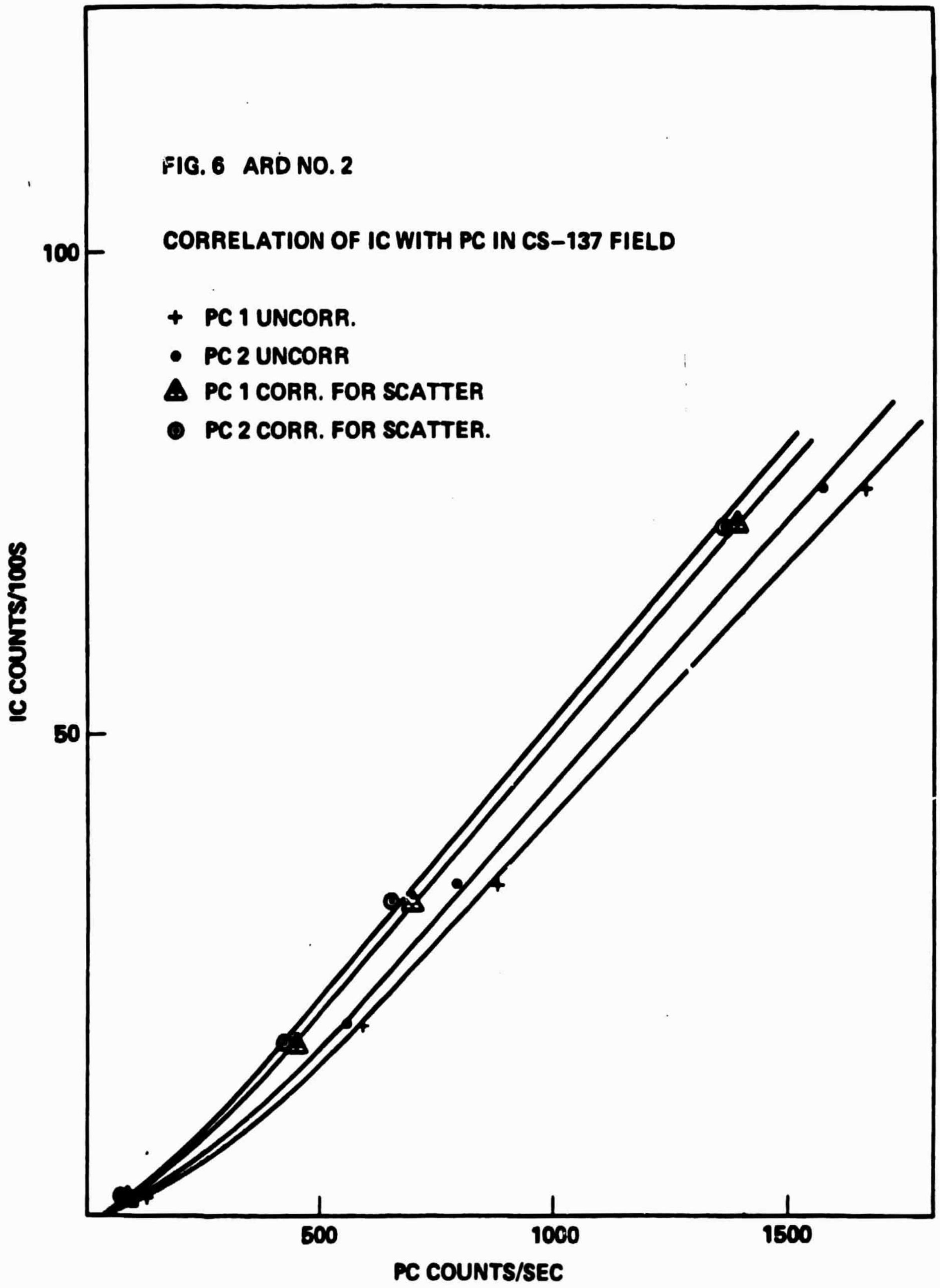


FIG. 6 ARD NO. 2
CORRELATION OF IC WITH PC IN CS-137 FIELD
+ PC 1 UNCORR.
• PC 2 UNCORR
PC 1 CORR. FOR SCATTER
PC 2 CORR. FOR SCATTER.
100
50
IC COUNTS/100S
500
1000
1500
PC COUNTS/SEC

Photomultiplier Tube Testing

Both the NRM and the Gamma-Ray Observatory will pass through the South Atlantic Anomoly (SAA) periodically. Scintillation crystals produce a high intensity flight under these conditions, and it is important to know the time - response of recovery of the PMT's and whether any permanent effect is obtained. Tests were performed on EMI-D611 tubes which are equivalent to EMI-9791 except the dynodes are of BeCu instead of being coated with CsSb.

Light Cone Apparatus:

The tubes were balanced on the light cone at flight gains which required high voltage settings that were from 50 to 120 volts below test ticket 50A/lumen voltages. Then the three PMTs were exposed to a bright Am241 source which has a peak at 60KeV. The resulting gain change at a count rate of 417kHz was 1.6% and a change of 9.3% at 1029kHz (compared with a 9791 mounted on a 5 x 5 crystal that changed 2.5% at a rate of 488kHz).

Measurements were also taken (at flight gains) to determine the charge deposited by a Na22 511KeV line (8.3pC). Using a calculated incident flux of 1 x 10 5^MeV/sec average charged-particle energy deposition in a 350kM orbit SAA exposure, an expected anode current of 1.6uA was calculated.

Measurements in PMTBOX:

In this box two things were studied: gain recovery after simulated SAA exposure and gain stability on periods of 12 hours.

The calculated SAA equivalent of 1.6uA produced no measurable gain change whether the high voltage was on or off. However, the original incident flux from which the current of 1.6uA was calculated, was deemed too low. Therefore, the rest of the SAA simulations were made at a higher light levels and correspondingly higher anode currents. Gain of the BeCu changed no more than one percent after a SAA with mean current 13uA with the High Voltage off during

the SAA exposure. The worst case gain recovery was 5 minutes. In comparison the 9791's, had a gain change significantly less than one percent but the gain did still change slightly. Recovery from this slight gain change was almost instantaneous. The difference in behavior of the two types of tubes became more pronounced when the high voltage was left on during the simulated SAA (13uA). The BeCu tubes showed gain increases of 7% (as opposed to the 9791 which showed a 3% gain decrease). Both tubes showed slow gain recovery after SAA exposures during which the high voltage was on. Worst case for the BeCu type tubes was, after three hours, a gain recovery of only 30% of the gain change. The only CsSb type tube observed, recovered 50% of the gain change after three hours.

The BeCu tubes showed stability (less than 1% gain change) over periods of twelve hours when the room temperature stayed constant (no fluctuation in temperature greater than 1/2 of a degree Celsius for the same 12 hours). When the temperature fluctuated 1 degree, the gain changed 2 percent for one tube and 4% for the other tube. This is not necessarily due to the tube as none of the other electronics were in a temperature controlled environment.

Conclusion:

Based on a sample of three BeCu tubes, there is no reason they could not be used in lieu of the 9791's. The slow recovery after SAA exposure is the only drawback seen, but this should not be a problem as long as the high voltage is turned off during SAA.

FINANCIAL REPORT

Total Cumulative coats incurred as of 1/31/85	$102,156.92
Estimate to complete	3,836.08
Estimated percentage of physical completion of contract	95%